72. There is no angular acceleration of bicycle about a line through cm parallel to velocity vector. Hence torque is zero, i.e. $F_N \sin\theta\, d = F_{fr}\cos\theta\, d$. $\tan\theta = F_{fr}/F_N$. (Note $F_{fr}/F_N = \mu$, so $\tan\theta = \mu$)

(b) $F_{fr} = mv^2/r$ for circular motion; $\tan\theta = v^2/rg$; $\theta = \arctan[(5.4\text{ m/s})^2/(4.9\text{ m})(9.8\text{ m/s}^2)] = \underline{31^\circ}$.

(e) $\tan\theta = (\mu mg/mg) = 0.65 = (5.4\text{ m/s})^2/r(9.8\text{ m/s}^2)$. Hence $r = 4.58\text{ m} = \underline{4.6\text{ m}}$.

73. (a) $W = Fd = Fr\Delta\theta = T\Delta\theta$.

(b) $P = Fv = Fr\omega = T\omega$.

(c) $P = (280\text{ N . m})(419\text{ rad/s})/(750\text{ W/hp}) = \underline{157\text{ hp}}$.

74. $$mgh = \frac{1}{2}mv^2 + \frac{1}{2}\left[\frac{2}{5}mr^2\right]\left[\frac{v}{r}\right]^2 + mg(2R_0)$$

$$gh = \frac{7}{10}v^2 + 2gR_0$$

At top, $v^2/R_0 = g$, so $v^2 = R_0 g$

$$gh = \frac{7}{10}(R_0 g) + 2R_0 g$$

$$h = \underline{2.7\, R_0}$$

75. $$mg(h+r) = \frac{1}{2}mv^2 + \frac{1}{2}\left[\frac{2}{5}mr^2\right]\left[\frac{v}{r}\right]^2 + mg(2R_0 - r)$$

$$g(h+r) = \frac{7}{10}v^2 + g(2R_0 - r)$$

At top, $v^2/(R_0 - r) = g$, so $v^2 = g(R_0 - r)$

$$(h+r) = \frac{7}{10}(R_0 - r) + (2R_0 - r)$$

$$h = 2.7\, R_0 - 1.7r - r$$
$$h = \underline{2.7(R_0 - r)}$$

76. $$Mg(L/2) = \frac{1}{2}Mv^2 + \frac{1}{2}\left[\frac{1}{12}ML^2\right]\omega^2$$

But $\omega = v/(L/2) = 2v/L$

$$MgL/2 = \frac{1}{2}Mv^2 + \frac{1}{24}ML^2(2v/L)^2 = \frac{1}{2}Mv^2 + \frac{1}{6}Mv^2$$

$$MgL/2 = \frac{2}{3}Mv^2$$

$$\underline{v = (3/4\, gL)^{\frac{1}{2}}}$$

Chapter 9

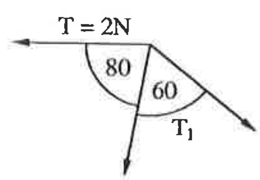
1. $2T(\cos 80^\circ) = 0.50$ N. $T = \underline{1.44 \text{ N}}$

2. $T = mgd = (70)(9.8)(3) = \underline{2.06 \times 10^3 \text{ Nm}}$

3. $m = (Tl)/(gl') = (12)(9.8)(0.36)/0.805/9.8 = \underline{5.37 \text{ kg}}$

4. $F_1 \cos 45^\circ = F_2$. Therefore F_1 is the bigger. $F_1 = 1200$ N. $1200 \sin 45^\circ = W = \underline{848 \text{ N}}$.

5. About end near piano, $(200)g(L/4) + (180)g(L/2) - F_N L = 0$.
   F_N = vertical force on a far end = $(140)(g) = \underline{1370 \text{ N}}$.
   Vertical force on near end = $200g + 180g - 140g = 240g = \underline{2350 \text{ N}}$

6. 

Resolve and balance forces perpendicular to desired re[illegible]nt.
$(2 \text{ N})(\sin 80^\circ) = T_1 \sin 60^\circ$. $T_1 = \underline{2.27 \text{ N}}$.

7. Resolve and balance forces perpendicular to each string.
   $T_R = (30 \text{ kg})(9.8 \text{ m/s}^2)(\cos 45^\circ)/(\sin 98^\circ) = \underline{210 \text{ N}}$.
   $T_L = (30 \text{ kg})(9.8 \text{ m/s}^2)(\cos 37^\circ)/(\sin 98^\circ) = \underline{240 \text{ N}}$.

8. $(20 + 25 + 30)(9.8) = 735$ N

9. $\Sigma\tau = F_2(20 \text{ m}) - mg(25 \text{ m}) = 0$.
   $F_2 = mg(25 \text{ m})/20 \text{ m}$.
   Torques about the left end: $F_2 = (1200 \text{ kg})(9.8 \text{ m/s}^2)(25 \text{ m})/(20 \text{ m}) = \underline{1.47 \times 10^4 \text{ N}}$.
   Torques about right support $F_1 = (1200 \text{ kg})(9.8 \text{ m/s}^2)(5 \text{ m})/20 \text{ m} = \underline{2.94 \times 10^3 \text{ N}}$.
   Check: $F_1 + F_2 - mg = 0$.

10. About lower hinge: $(13)(g)(0.65) - H_U(1.5) = 0$.
Horizontal component: $H_L = -H_U$
Solving, H_U = 55.2 N, i.e. pulling. H_L = – 55.2 N, i.e. pushing.
$V_U = V_L = (13)g/2$ = 63.7 N, i.e. upward.

11. Torques about left support F_R = (50 kg)(9.8 m/s²)(4 m)/(1 m) = 1960 N up.
Torques about right support F_L = –(50 kg)(9.8 m/s²)(3 m)/(1 m) = –1470 N. F_L = 1470 N down.
Check: $\vec{F}_R + \vec{F}_L = m\vec{g}$.

12. Torques about left support F_R = [(50 kg)(9.8 m/s²)(4 m) + (40 kg)(9.8 m/s²)(2 m)]/(1 m) = 2740 N up.
Torques about right support F_L = [–(50 kg)(9.8 m/s²)(3 m) – (40 kg)(9.8 m/s²)(1 m)]/(1 m).
F_L = –1862 N up = 1860 N down.

13. Cm of leg is (20.4/100)(1.7 m) = 0.347 m from hip joint;
mass of leg is (17.25/100)(88.5 kg) = 15.3kg;
distance of ankle to hip joint is (48.1/100)(1.70 m) = 0.818 m.
Now torques about joint gives T = (15.3 kg)(9.8 m/s²)(0.347 m)/(0.818 m) = 63.6 N.
$m = T/(9.8\ \text{m/s}^2)$ = 6.49 kg.

Torques about left support:
F_2 = [(4000)(2) + (280)(9.8)(5) + (3000)(6) + (2000)(9)]/10 = 5772 N = 5.8×10^3 N.
F_1 = (280)(9.8) + 4000 + 3000 + 2000 – 5786 = 5958 N = 6.0×10^3 N.

15. Torques about left end: $F_T = (20)(9.8)(L/2)/(L \sin 45°)$ = 140 N.
Resolve and balance components horizontally: $F_W \cos\theta = F_T \sin 45°$.
Torques about right end: $F_W = (20)(9.8)(L/2)/(L \sin\theta)$.
Solving, $F_W = F_T$ = 140 N, θ = 45°.

16. Let cm be $d(m)$ from head. Take torques about cm. $(32.8\text{ kg})gd - (29.4\text{ kg})g(1.60\ m - d) = 0$.
d = 0.76 m.

17. (a) Ropes make angle with vertical θ = arc tan(6.25/2) = 72.3°.
Resolving and balancing vertical forces: T = (18)(9.8)/2/cos 72.3° = 290 N

(b) θ = 88.2°. T = (18)(9.8)/2/cos 88.2° = 2.8×10^3 N.

18. Torques about A: $T = [(5)g(2.25 \cos 53°) + (10)g(4.5 \cos 53°)]/0.8$ = 415 N.
N_H = 415 N. $N_V = 5(g) + 10(g)$ = 147 N.

19. x–forces: $F_{Gx} - F_W = 0$ $F_{Gx} = F_W$
y–forces: $F_{Gy} - mg = 0$ $F_{Gy} = mg$
Friction: $F_{Gx} = \mu F_{Gy} = \mu mg = F_W$
Take pivot at ground.
Torques: $F_W\, L \sin\theta - mg(L/2)\cos\theta = 0$

$$\mu mg\, L \sin\theta = \frac{1}{2} mg\, L \cos\theta$$

$$\theta = \tan^{-1}(1/(2\mu))$$

20. (a) Torques about 90–cm mark: $T_0 = (0.35)g(0.4)/0.9 = 1.52$ N.

(b) $T_{90} = (0.35)g - 1.52 = 1.91$ N

(c) About 90–cm mark: $I = ML^2/12 + M(0.4L)^2 = 0.243\, ML^2$. $\alpha = Mg(0.4\, L)/0.243\, ML^2 = 1.64\, g/L$
$A_{cm} = 0.4L\ \alpha = 0.66g$. But $Mg - T = MA_{cm}$. Thus $T = 0.34Mg$ = 1.17 N.

21. L = distance up ladder. $y = \left(\frac{4}{5}\right)L$

x–forces: $F_{Gx} - F_W = 0$ $F_{Gx} = F_W$
y–forces: $F_{Gy} - mg - Mg = 0$ $F_{Gy} = (m + M)g = (70\text{ kg})(9.80\text{ m/s}^2)$
Take pivot at ground. $F_{Gy} = 686$ N
Torques: $F_W(4.0\text{ m}) - (12.0\text{ kg})(9.80\text{ m/s}^2)(1.5\text{ m}) - (58\text{ kg})(9.80\text{ m/s}^2)(3/5\ L) = 0$
$F_W(4.0\text{ m}) = 176.4\text{ N . m} + (341\text{ N})L$
Friction: $F_{Gx} = \mu F_{Gy} = (0.40)(686\text{ N}) = 274.4\text{ N} = F_W$
L = 2.70 m along ladder.

22. (a) (i) Force required to slip = 0.2 mg.
(ii) Force required to tip (about far corner at base) is found by taking torques about that point and realising this is where floor–lamp reaction force acts. Force = $mg(0.1\text{ m})/(0.6\text{ m}) = 0.167\ mg$. As force required to tip is less than to slip lamp tips first.

(b) Repeat calculation but equate slip and tip forces: $mg(0.1\text{ m})/h = 0.2\ mg$. h = 0.5 m.

23. The angle the guy rope makes with a horizontal line joining the base of pole to where the rope is anchored is arc tan (2.4 m/2 m) = 50.2°. All we have to do now is balance the two 85 N components with the net tension. The component of the 85 N along the horizontal line is (85 N)(cos 50.2°). Resolving both of these again in the net–line direction gives 2(54.4 N)(cos 30°) = T = 94 N.

24. Torques about the elbow joint:
$m = [(400\text{ N})(0.06\text{ m}) - (2.0\text{ kg})(9.8\text{ m/s}^2)(0.15\text{ m})]/(0.35\text{ m})/(9.8\text{ m/s}^2)$ = 6.14 kg.

25. Torques about elbow joint:
F_M = [(2.8 kg)(9.8 m/s²)(0.12 m) + (7.3 kg)(9.8 m/s²)(0.3 m)]/(0.025 m) = 990 N.

26. Torques about elbow jont: F_M = (2.8 kg)(9.8 m/s²)(0.24 m)/(0.12 m)/(sin 15°) = 212 N.

27. F_M = [(2.8 kg)(9.8 m/s²)(0.24 m) + (10 kg)(9.8 m/s²)(0.5 m)]/(0.12)/(sin 15°) = 1790 N.

28. Problem 26. F_T (Horizontal) = F_M(cos 15°) = 205 N.
F_J (Vertical) = (2.8 kg)(9.8 m/s²) − (212 N)(sin 15°) = −27.4 N up. F_J = 207 N.
Problem 27. F_J (Horizontal) = F_M(cos 15°) = 1730 N.
F_J (Vertical) = (12.8 kg)(9.8 m/s²) − (1790 N)(sin 15°) = −338 N up. F_J = 1763 N.

29. For this problem w_1 = 48 N, w_2 = 278 N, w_3 = 316 N.
Torques about the spine:
F_M = [(48 N)(0.72 m) + (278 N)(0.48 m) + (316 N)(0.36 m)](sin 60°)/(0.48 m)/(sin 12°)
= 2445 N.
F_V (Horizontal) = F_M(cos 18°) = 2325 N.
F_V (Vertical) = w_1 + w_2 + w_3 + F_M(sin 18°) = 1398 N.
F_V = 2700 N at 31.0° to horizontal.

30. Torques about joint: F_M = [(700 N)(0.1 m) − (90 N)(0.025 m)]/(0.075 m)/(sin 70°) = 961 N.
F_J (Horizontal) = F_M(cos 70°) = 329 N.
F_J (Vertical) = F_M(sin 70°) + 700 N − 90 N = 1513 N (down).

31. (a) The only effect of the suitcases is to change the weight of the person to 700 N + 2(20 kg)(9.8 m/s²) = 1092 N. Repeating the calculations gives F_M = 1500 N.
F_J (Horizontal) = F_M(cos 70°) = 520 N. F_J (Vertical) = F_M(sin 70°) + 1092 N − 90 N = 2400 N.

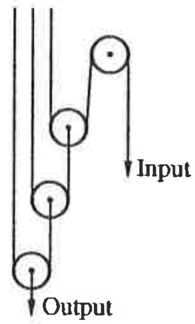
(b) New position of cm measured from middle line of body,
X = (20 kg)(9.8 m/s²)(0.175 m)/[700 N + (20 kg)(9.8 m/s²)] = 0.038 m. Now repeat calculation. New w = 896 N. The leg has swung through an angle but as we do not know where F_M is attached to the body we neglect this change in 70°. The leg has moved from 0.025 m to approximately 0.025 m + 0.038/2 m = .044 m from the joint line.
Thus F_M = [(896 N)(0.138 m) − (90 N)(0.044 m)]/(0.075 m)/(sin 70°) = 1700 N.
F_J (Horizontal) = 580 N. F_J (Vertical) = 2400 N.

32. IMA = (35 cm)/(2 cm) = 17.5.

33. Approximately F = [(200 kg)(9.8 m/s²)(1 m) − (12 kg)(9.8 m/s²)(1.5 m)]/(4 m) = 446 N.

34. $IMA = (2\pi r_2)/P$, because the car lifts P every time the handle goes through 2π radians.

35.



$(d_i/d_o) = (F_o/F_1)/\text{efficiency} = (80/18)/0.75 \simeq 6$. The pulley arrangement shown gives d_i/d_o of 8 which is suitable to handle load.

36. $F_o = (\text{efficiency})F_i d_i/d_o = (0.80)(50\ \text{N})(38\ \text{cm})/(2.5\ \text{cm}) = 608\ \text{N}$.

37. (a) $IMA = d_i/d_o = \ell/\ell \sin 15° = 3.9$.

(b) $AMA = F_o/F_i = (mg)/(mg \sin 15° + 0.40\ mg \cos 15°) = 1.5$.

38. (a) $IMA = \dfrac{d_i}{d_o} = \dfrac{2\pi r_P}{(T_P/T_r)2\pi r_w}$

$$IMA = \left[\frac{T_r}{T_P}\right]\left[\frac{r_P}{r_w}\right]$$

(b) $d_o = \left[\dfrac{T_P}{T_r}\right]2\pi r_w$.

39.

T_P:T_R	IMA =	d_o =	
52:13	0.13	8.5 m	12
52:15	0.15	7.4 m	11
52:17	0.17	6.5 m	9
52:20	0.20	5.5 m	7
52:24	0.24	4.6 m	5
52:28	0.28	4.0 m	3
42:13	0.16	6.9 m	10
42:15	0.19	6.0 m	8
42:17	0.21	5.3 m	6
42:20	0.25	4.5 m	4
42:24	0.30	3.8 m	2
42:28	0.35	3.2 m	1

40. $F_i = 0.75\ w$
$F_o = (IMA)F_i$ (Assumed)
want $F_o = 1.20\ w \sin\theta$
so $\theta = \text{arc sin}\ [0.625\ (IMA)]$

52:13	θ = 4.73°
52:15	5.49°
52:17	6.21°
52:20	7.33°
52:24	8.77°
52:28	10.26°
42:13	5.88°
42:15	6.78°
42:17	7.69°
42:20	9.06°
42:24	10.92°
42:28	12.75°

41. $IMA = 0.353$
$F_o = 1.16\ mg \sin(15^\circ) = 0.300\ mg$
$F_o = (IMA)F_i$
$F_i = 0.85\ mg$

42. The cm is 2.25 m off center, i.e. (3.5 m − 2.25 m) = 1.25 m from base edge. Thus it is stable.
It would have to lean so $d = 2(3.5\ \text{m})$ to become unstable, i.e. 7 m.
This is (7 m − 4.5 m) = 2.5 m farther.

43. (a) First brick has cm (1/2) from edge so this is its balance point. The two bricks now have a cm measuring from edge of supporting brick $x = [(0 + m(1/2)]/2\ \text{m} = 1/4$ from edge; so this is the balance point. The three brick system has cm distance $x = [0 + m/2]/3 = 1/6$. This continues as $1/(2n)$.

(b) The "in" end of the top brick is (1/8 + 1/6 + 1/4 − 1/2) beyond the base by (1/24) a brick length.

(c) The distance spanned beyond the edge of the table by n brick is $\sum_1^N (1/2\ n)$. Note this harmonic series diverges as N goes to infinity.

(d) $n = 16$ gives $d = (0.3\ \text{m})\Sigma(1/2\ n) = 0.507\ \text{m}$ so 32 bricks make arch.

44. Stress = Force/Area = (20,000 kg)(9.8 × m/s²)/2m² = $9.8 \times 10^4\ \text{N/m}^2$.
Strain = Stress/E = $(9.8 \times 10^4\ \text{N/m}^2)/(50 \times 10^9\ \text{N/m}^2) = 1.96 \times 10^{-6}$.

45. $\Delta L = (1.96 \times 10^{-6})(10\ \text{m}) = 2.0 \times 10^{-3}\ \text{cm}$.

46. $F = (200 \times 10^9)\pi(0.025 \times 10^{-2})^2(0.025)/100 = \underline{9.82\ \text{N}}$.

47. $T_L = (30\ \text{kg})(9.8\ \text{m/s}^2)(\sin 53°)/(\sin 82°) = 240\ \text{N}$,
$T_R = (30\ \text{kg})(9.8\ \text{m/s}^2)(\sin 45°)/(\sin 82°) = 210\ \text{N}$.
Thus $(\Delta L/L)100 =$ (i) $(100)(237\ \text{N})/\pi/(0.5 \times 10^{-3}\ \text{m})^2/(200 \times 10^9\ \text{N/m}^2) = \underline{0.15\%}$.
(ii) $(0.151\%)(210\ \text{N})/(237\ \text{N}) = \underline{0.13\%}$.

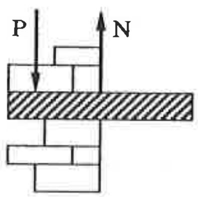
48. $E = FL_o/A\Delta L = (13.4\ \text{N})(.15\ \text{m})/\pi(4.25 \times 10^{-3}\ \text{m})^2(3.7 \times 10^{-3}\ \text{m}) = 9.6 \times 10^6\ \text{N/m}^2$

49. $P = (90 \times 10^9\ \text{N/m}^2)(0.10)/(100) = \underline{9 \times 10^7\ \text{N/m}^2} = \underline{900\ \text{atm}}$.

50. $\Delta V = (1000\ \text{cm}^3)(2.4 \times 10^6\ \text{N/m}^2)/(1.0 \times 10^9\ \text{N/m}^2) = 2.4\ \text{cm}^3$. $V = 1000\ \text{cm}^3 - 2.4\ \text{cm}^3 = \underline{997.6\ \text{cm}^3}$

51. $k = F/\Delta L = (2.0 \times 10^6\ \text{N/m}^2)(0.50 \times 10^{-4}\ \text{m}^2)/(3 \times 10^{-3}\ \text{m}) = 3.33 \times 10^4\ \text{N/m}$.
Energy stored $= kx^2/2 = (3.33 \times 10^4\ \text{N/m})(10^{-3}\ \text{m})^2/2 = \underline{1.7 \times 10^{-2}\ \text{J}}$.

52. (b)



(a) Torque is $(4.5\ \text{kg})(9.8\ \text{m/s}^2)(2.4\ \text{m}) = \underline{106\ \text{N}\cdot\text{m}}$.
(c) Considering the pole embedded in the wall there is compression and shear stress.

53. $F = (170 \times 10^6\ \text{N/m}^2)(3 \times 10^{-4}\ \text{m}^2) = \underline{5.1 \times 10^4\ \text{N}}$.

54. Stress is $(3 \times 10^4\ \text{N})/(3.6 \times 10^{-4}\ \text{m}^2) = 8.33 \times 10^7\ \text{N/m}^2$. This is less than $(170 \times 10^6\ \text{N/m}^2)$ so answer is

(a) <u>No</u>.

(b) $\Delta\ell = (20\ \text{cm})(8.33 \times 10^7\ \text{N/m}^2)/(15 \times 10^9\ \text{N/m}^2) = \underline{0.111\ \text{cm}}$.

55. $A = 6(280)(9.8)/(500 \times 10^6) = 3.29 \times 10^{-5}\ \text{m}^2$, or $\underline{0.33\ \text{cm}^2}$.

56. F_1 = (5200)(9.8)(5)/20 = 12740 N, down. F_2 = 63700 N, up.
Left hand pier is under tensile stess. $A = (8.5)(12740)/(40 \times 10^6) = 2.71 \times 10^{-3}$ m², or 27.1 cm².
Right pier is under compressive stress. $A = 8.5(63700)/(35 \times 10^6) = 1.55 \times 10^{-2}$ m², or <u>155 cm²</u>.

57. $\pi(d/2)^2 = 7(2000)/(170 \times 10^6)$. Hence d = 0.0102 m, or <u>1.02 cm</u>.

58. Tension is a max when acceleration is up

$T = mg + ma$

T = 2800 kg(9.8 + 1)m/s².

$$\text{Max tension} = \frac{500}{6} \times 10^6 \text{ N/m}^2.$$

$$\frac{T}{A} = \frac{500}{6} \times 10^6 \text{ N/m}^2$$

$$A = \frac{6T}{500 \times 10^6} \Rightarrow$$

$$d^2 = \frac{24\ T}{\pi \times 500 \times 10^6} = \frac{24(2800\text{ kg})(10.8\text{ m/s}^2)}{\pi \times 500 \times 10^6}$$

d = <u>2.15 cm</u>

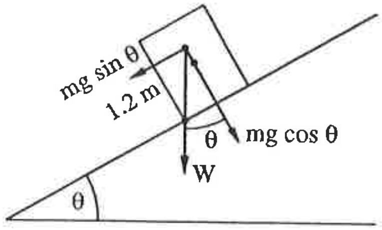
59. The lever arm for the round arch is 4 m. The arm for the pointed arch must be 3(4 m) = <u>12.0 m</u>.

60. $T = 4.3 \times 10^5$ N)/2/sin 5° = <u>2.47×10^6 N</u>.

61. To get F_a we must multiply the force per area by the total area:
F_a = (1450 N/m²)(70 m)(200 m) = 2.0×10^7 N. We calculate the torque about the potential pivot point, the lower rear edge of the building. The wind, as we saw above, can be considered to act at the midpoint of the face, which is 100 m above the ground. The torque it produces, tending to overturn the building, is equal to (100 m)(2.0×10^7 N) = 2.0×10^9 N·m. The torque tending to keep the building upright is the force of gravity acting through a lever arm equal to half the width of the building, or 20 m; this torque equals (20 m)(1.5×10^8 N) = 3.0×10^9 N·m. The building will not tip over, but it is close; a safety factor of two or more would be better.

62. θ = arc tan(3.0 m/20.0 m) = 8.53°
$2F_T \sin(8.53°) - (60\text{ kg})(9.80\text{ m/s}^2) = 0$
F_T = 1980 N
No, there will always be some sag.

63.



To prevent toppling weight must act within base or stability.

$mg \sin \theta \times 1.2\text{ m} = mg \cos \theta \times 1.0\text{ m}$

$\tan \theta = \dfrac{1}{1.2}$

$\theta = 40°$.

If crate were sliding at constant speed (no acceleration) the angle is the same.

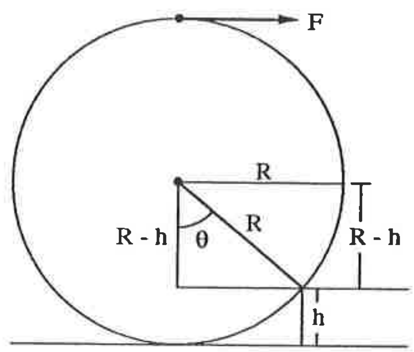
64. (a) Applied torque $= F(2R - h)$

Gravitational torque $= MgR \sin \theta$ where $\cos \theta = \dfrac{R-h}{R}$

$\sin \theta = [R^2 - (R-h)^2]^{\frac{1}{2}}/R = [R^2 - R^2 + 2Rh - h^2]^{\frac{1}{2}}/R = [2Rh - h^2]^{\frac{1}{2}}/R$

So $F(2R - \text{h}) = Mg[2Rh - h^2]^{\frac{1}{2}}$

$F = \dfrac{Mg(2R-h)^{\frac{1}{2}}h^{\frac{1}{2}}}{2R-h} = \underline{Mg\left[\dfrac{h}{2R-h}\right]^{\frac{1}{2}}}$



(b) $F(R-h) = Mg[2Rh - h^2]^{\frac{1}{2}}$

$F = \underline{\dfrac{Mg[2Rh - h^2]^{\frac{1}{2}}}{R-h}}$

65. (a) $F(0.01\text{ m}) = mgh = (70\text{ kg})(9.8\text{ m/s}^2)(5\text{ m})$.
Hence stress on each leg $[3.43 \times 10^5\text{ N} + (70\text{ kg})(9.8\text{ m/s}^2)]/(3 \times 10^{-4}\text{ m}^2)/2 = \underline{5.8 \times 10^8\text{ N/m}^2}$, on each leg.

(b) Break.

(c) $F = (mgh)/d = 6860$ N. Total force $= 6860 + mg = 7546$ N.
Hence stress is $\underline{1.15 \times 10^7\text{ N/m}^2}$ on each leg. Will not break.

66. Force design of stud is $(1/15)(35 \times 10^6)(4 \times 9 \times 10^{-4}) = 8400$. Number $= (14100)(9.8)/8400 = 16.45$. However must be divisible by 2, so use 18 studs, i.e. 9 studs on each 10-m sides, 1.25 m apart.

67. Horizontal: $T_1 \cos 19° = T_2 \sin 60°$
Vertical: $T_2 \cos 60° = mg + T_1 \sin 19°$
Solving, $T_2 = \underline{4.96\ mg}$, $T_1 = \underline{4.54\ mg}$.
$h = (d_1/2)(\tan 19° + \tan 30°) = \underline{158\text{ m}}$.

68. (a) $W(5) = 500(5)$, i.e. $W = \underline{500\text{ N}}$.

(b) $F_A = 0$; $F_B = \underline{1000\text{ N}}$

(c) Torques about B: $F_A = [(500)(5) - (500)(2)]/10 = 150$ N. $F_B = 500 + 500 - 150 = \underline{850\text{ N}}$.

(d) Torques about B: $F_A = [(500)(5) + (500)(8)]/10 = \underline{650\text{ N}}$. $F_B = \underline{350\text{ N}}$.

69. $2T_A \sin\theta = mg$; $T_A \cos\theta = T_L$. Thus

(a) $T_L = \underline{\dfrac{mg}{2\tan\theta}}$, horizontal, and

(b) $T_A = \underline{mg/2/\sin\theta}$, along cable, i.e. at θ to horizontal.

70. Place mass symmetrically between two legs on the edge of table. It is furthest away from the line joining the two legs here. The lever arm of the cm of the table from this line is $r\cos 60°$. The lever arm of the weight from this line is $r(1 - \cos 60°)$. When the table is about to tip all the weight is supported on this line and no normal force is on third leg.
Thus $m = (30\text{ kg})(\cos 60°)/(1 - \cos 60°) = \underline{30\text{ kg}}$.

71 Assume bridge is totally symmetric.
$M_1 = \lambda d_1 g$, $M_2 = \lambda d_2 g$, where λ = mass/length of roadway.
At tower: $T_2\cos(60) + T_3\cos(66) - \lambda d_1 g - \lambda(d_2/2)g = 0$
$T_2\sin(60) - T_3\sin(66) = 0$
At shore: $T_2\sin(60) - T_1\cos(19) = 0$
Along North cable: $T_2\cos(60) - T_1\sin(19) - \lambda d_1 g = 0$
Along center cable: $2T_3\cos(66) - \lambda d_2 g = 0$

Solving, $d_2/d_1 = \dfrac{2\cot(66)}{\cot(60) - \tan(19)} = \underline{3.82}$

72. (a) Vertical component (supports all weight) equals $(18)(9.8) = \underline{176\text{ N}}$.
Horizontal component is F_W in equilibrium.
Take torques about ladder base:
$F_W = (18)(9.8)\sin 20°(4.25\text{ m})/\sin 70°/8.5\text{ m} = \underline{32.1\text{ N}}$.

(b) Vertical force at base $= (75 + 18)(9.8) = 911$ N. Take torques about ladder base.
$F_W = [(18)(9.8)(\sin 20°)(4.25) + (75)(9.8)(\sin 20°)(6.375)]/\sin 70°/8.5 = 232$ N. This is equal to horizontal forces at ladder base. Hence $\mu = 232/911 = \underline{0.225}$.

73. Vertical force is 911 N. Horizontal force is $0.3(911\text{ N}) = \underline{273\text{ N}}$. Torques about base of ladder:
$L = [(273\text{ N})(\sin 70°)(8.5\text{ m}) - (18\text{ kg})(9.8\text{ m/s}^2)(\sin 20°)(4.25\text{ m})]/(75\text{ kg})/(9.8\text{ m/s}^2)/(\sin 20°) = \underline{7.7\text{ m}}$.

74. Stress = $F/A = (Ah\rho)g/A = h\rho g$. Hence

(a) $h = (500 \times 10^6\ \mathrm{N/m^2})/(7.8 \times 10^3\ \mathrm{kg/m^3})/(9.8\ \mathrm{m/s^2}) = \underline{6541\ \mathrm{m}}$.

(b) $(170 \times 10^6\ \mathrm{N/m^2})/(2.7 \times 10^3\ \mathrm{kg/m^3})/(9.8\ \mathrm{m/s^2}) = \underline{6425\ \mathrm{m}}$.

75. Neglect energy loss due to sound on initial impact.
Force is $(35 \times 10^6\ \mathrm{N/m^2})(15 \times 6 \times 10^{-4}\ \mathrm{m^2}) = 3.15 \times 10^5\ \mathrm{N}$.
Compression distance = $(0.04\ \mathrm{m})(35 \times 10^6\ \mathrm{N/m^2})/(14 \times 10^9\ \mathrm{N.m^2}) = 1 \times 10^{-4}\ \mathrm{m}$.
$h = (3.15 \times 10^5\ \mathrm{N})(10^{-4}\ \mathrm{m})/(1.2\ \mathrm{kg})/9.8\ \mathrm{m/s^2} = \underline{2.7\ \mathrm{m}}$.